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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

OAST SPACE THEME WORKSHOP

VOLUME II

(NASA-TM-80002) OAST SPACE THEME WORKSHOP.
VOLUME 2: THEME SUMMARY. 1: SPACE POWER
(NO. 7). A. THEME STATEMENT. B. 26 APRIL
1976 PRESENTATION. C. SUMMARY. D.
INITIATIVE ACTION (NASA) 35 p HC A03/MF A01 G3/12

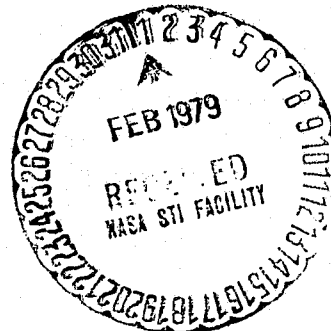
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THEME SUMMARY

- I. SPACE POWER (#7)
 - A. THEME STATEMENT
 - B. APRIL 26, 1976, PRESENTATION
 - C. SUMMARY
 - D. INITIATIVE ACTION

HELD AT THE
LANGLEY RESEARCH CENTER
APRIL 26-30, 1976



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Foreword

The attached material represents the working papers from the OAST Space Theme Workshop held at the Langley Research Center, April 26-30, 1976, and contains a quick-look analysis of the proceedings. The material is unedited and intended for further use by the participants of the workshop and the planning elements of NASA concerned with space mission research and technology. It should be understood that the data do not represent official plans or positions but are part of the process of evolving such plans and positions.

Nearly 100 of the Agency's top technologists and scientists joined with another 35 theme specialists to produce this working document - a document that provides a technical foundation, including research and technology base candidates, for each of the six space themes.

The material in this report is considered essential to the development of Center initiatives in support of these themes. Copies of the report will be made available to the Center Management Board and the individuals at the Centers responsible for the FY'78 program planning cycle. The timing of this planning activity has caused us to distribute this document in this unedited form. Thus, it possibly contains errors, hopefully, more of a typographical rather than a technological nature. Nonetheless, the information contained is of a high professional level, reflecting the efforts of the workshop participants and will be invaluable to the planning and successful execution of the Agency's near- and far-term advanced technology program.

Stanley R. Sadin
OAST Space Theme Workshop
Chairman
NASA Headquarters
Study, Analysis, & Planning Office
Office of Aeronautics and
Space Technology

SPACE TECHNOLOGY THEME

MULTIPURPOSE SPACE POWER PLATFORM

(07)

DESCRIPTION

The Multipurpose Space Power Platform (MSPP) concept assumes the eventual beneficial use of central space power plants to meet energy needs of missions in space. The MSPP would provide energy for such functions as life support, space manufacturing, experimentation, communications, and include transmission to other space vehicles and stations.

In one view of the future of this concept, the requirements for MSPP's would evolve to meet eventual power needs for missions in space. In this case, while the MSPP's would certainly provide technology and operational experience related to Satellite Power Stations (SPS) for terrestrial utility use, there would be no schedule impact of SPS on the early phase of the MSPP planning. That is, a decision to proceed with specific SPS technology development would be delayed indefinitely while the MSPP effort proceeds to meet space needs.

On the other extreme, the needs of SPS could dominate particularly if a time period of the late 1990's is assumed for first operational use of an SPS. This schedule target has been used in NASA planning for SPS technology. These two extreme views of the future needs for space power systems lead to two strawman schedules, figures 1 and 2, for consideration in technology planning. Figure 1 assumes a space-mission focus for the MSPP concept; whereas figure 2 illustrates the impact on power technology when early operation of an SPS is assumed. In this draft, a space-mission focus is assumed for technology needs.

Mission Applications in Space for MSPP

In concept, the MSPP is an independent, long-lived space-based system that converts on-orbit solar and/or nuclear energy to a suitable form for distribution to using space systems. Initially, MSPP's would be launched as a single shuttle payload. As power demands grow, assembly and, perhaps, fabrication or manufacture would be employed to construct MSPP's of the future. Uses and deployment of MSPP's will depend on the availability of manned space stations and bases.

The energy thus provided by MSPP's furnishes part or all of users needs for electric power. Platforms for use in the 80's will have power conversion capability in the 10's of kW range and will lead to more advanced platforms having higher power capability, large energy storage capability and utilizing advanced energy transfer concepts.

A. Mission applications which might benefit from this theme:

1980's

- Space processing
- All Shuttle missions where power/energy requirements exceed Shuttle capability
- All Shuttle missions where costs to launch Shuttle power/energy capabilities are excessive.
- All free flyer spacecraft where the economics of a MSPP prevail over using individual power systems.

1990's

- Continuation of 1980's missions
- Higher orbit applications
- Hundreds of kilowatts applications
- Laser powered rockets
- Space construction needs

2000's

- Continuation of 1990's missions
- Space or lunar colonization

B. Scenario

In the 1980's a space power platform could become operational. To meet this timetable, this first generation space power station

would necessarily use, for the most part, existing technology. Operation would be relatively simple, a solar array of perhaps the 20 kW to 100 kW class could provide the energy to the user either as electricity or in a stored form via docking. Operations would take place in low-earth orbit and perhaps could involve a fleet of power platforms. Some means of orbital transportation for rendezvous purposes would be required of either the power platforms or the users so that multiple users could be serviced.

By the 1990's advanced generations of space power platforms could be realized. The power range would likely be in the hundreds-of-kilowatts range. Very large solar arrays, or, also likely, solar thermal techniques with rotating machinery such as Brayton cycle, could generate the power. Synchronous orbits could be attained by the power platforms. Microwave radiation to the user could become practical early in the decade and thus obsolete the propulsion systems needed earlier for direct power transfer.

Nuclear or solar sources could provide power in the megawatt range by the post 2000 era. Power transfer by laser is predicted possible in an early state by 1995 and would open up new space opportunities.

Mission Requirements

The power/energy requirements on a space platform for the 1980's are expected to be inextricably tied to Shuttle users. Current Shuttle plans to provide only 7 kW continuous and 12 kW peak power, energy of 50 kWh with 840 kWh add-on kits, and two-week mission times undoubtedly discourage some potential high power, long mission users. For example, a recent JSC study* reportedly identifies a potential need for from 2,300 to 68,000 kWh/year in the late 80's for space processing alone. Shuttle/Spacelab traffic are estimated to be \$1,721/kWh for a yearly cost of from 4M to \$115M. Consequently, a space-based power platform capability that improves upon the Shuttle capabilities and costs would find many interested potential users.

By the 1990's space processing may grow to require hundreds of kilowatts per process. Construction of large objects in space could require huge amounts of power for welding, for lighting during eclipses and for other

*Aviation Week, April 5, 1976, pg 52

assembly needs. Also, laser powered rockets could effectively use large amounts of power. Appendix A presents estimates of power needs for these applications.

During the post-2000 era the expected need for space derived power is unlimited. Colonization in space or on the moon, and eventual power transmission to Earth are examples of megawatt applications.

ADVOCACY

Issues/Problems

Issues that drive advocacy of the MSPP approach

- . High cost of energy transportation to orbit
 - . Eventual need for large power supplies for space missions
 - . Solar energy is available in orbit, if tapped - does not diminish Earth resources
- Should all NASA technology efforts in power be directed at this theme? If so, how?
- How to convince potential users of reliability and availability of power platform for their use?
- Should this theme be ultimately aimed at SPS which probably rules out nuclear? Or should the nuclear be picked up again even though it may not lead to SPS?
- Will the need for power in space continue to grow as expected?
- Is the lack of space power inhibiting space activities now? Will it in the future?
- Should NASA go for an early (1980's) space power platform with current technology and the resulting "simple" system, or should NASA go for a more sophisticated approach aimed at a later time?
- How would energy costs be paid for, i.e., will users pay on a kWh used basis?

Benefits

- Less \$/kWh for users encourages greater space exploitation to meet human needs
- Launch weight capabilities can be used for productive hardware instead of round tripping power systems
- Use of solar energy for space reduces exhaustion of Earth's energy resources. (technology for SPS)
- New space capabilities, eg. laser propulsion, nuclear electric propulsion
- Stimulation of advanced technology developments with high payoff in commercial applications on Earth

1980's

- Removes one serious restraint now impeding space processing
- Permits extended life (greater than two weeks) of Shuttle missions without paying launch weight penalty for add-on power kits
- Enforces the need for 20 kW to 100 kW class solar array and possibly the prime and auxiliary electric propulsion now in technology program
- Might make it practical to use existing ground designed processing or manufacturing equipment in space - saves redesign costs
- Unlimited power from Sun might diminish the need for super-high power handling efficiencies, i. e., space platform design costs might be low
- Uses current technology to obtain operational and planning experience for future.

1990's

- Laser rockets may be possible
- First application for microwave and/or laser energy transfer

- Can provide power to aid in construction of large space structure, possibly its own successor. Permits construction to continue throughout eclipse
- Development of advanced nuclear power units would support advanced propulsion systems

2000's

- Colonization, very large space factories

TECHNOLOGY "THRUSTS" (BROAD)

Description

- Mission planning for MSPP concepts
- Large lightweight solar photovoltaic systems (radiation resistance)
- Advanced high power conditioning capability
- High capacity, recyclable energy storage systems
- Laser and microwave power transmission
- New space-to-space energy transfer systems
- Advanced space power sources/converters for space-based systems
- Advanced attitude control techniques for large, flat structures
- Operational techniques, attitude control, and station keeping during MSPP assembly
- Propulsion and attitude control of MSPP during orbital transfer

NEEDS (INITIATIVES)

The technology areas of emphasis given below plus the description of broad technology "thrusters" above provides a preliminary check list for evaluating on-going technology efforts and planning new initiatives and program augmentations.

Technology Areas of Emphasis

1. High efficiency, low cost, large scale power conversion systems.
2. Advanced high capacity energy storage methods.
3. Assembly, attitude/thermal control of large scale, lightweight space structures.
4. Advanced material technology
5. Transparent structure technology (microwave)
6. High power, free space power transmission
7. High power, space, power distribution and control
8. Precision pointing and navigation
9. Power transmission antenna rotary joints
10. Heat rejection/thermal control systems
11. High efficiency absorbers/receivers
12. Thin film solar concentrators
13. Magnetic compensation systems
14. Spacecraft charging control
15. Large momentum exchange devices
16. Large structure active surface control
17. Large structure alignment sensing and determination
18. Advanced power supplies
19. Antenna Rotary Joint
20. Rectenna Design/maintenance

FY 1978 Candidate New Starts (MSPP)

1 - OASIS Study (122) Lewis Research Center

	FY 77	FY 78	FY 79	FY 80
Funding (Total)	0-.25	1.5	3.0	2.6
Manpower	8	11	14	14

This new start is a study to determine the needs, feasibility, and conceptual configurations of long-life, orbiting electrical power utility stations for multimission space applications. The study will consider evolution of the concept from initial uses to replenish and augment spacecraft electrical power to the use of the power platform as a continuous supplier of power for space stations, space industrialization, and space propulsion. The likely power range for these applications is from 10-100 Kw for initial uses to megawatts in the long term.

2 - Nuclear Thermionic Power System Technology (106) (319)
JPL and LeRC

	FY 78	FY 79	FY 80	FY 81	FY 82
Funding (Total)	3.0	3.7	3.3	2.7	1.0
Manpower	10	15	20	20	20

This new initiative augments a current OAST effort to provide demonstration of technology readiness for power system development in the early 1980's. A non-nuclear test of an advanced power conversion module would be conducted along with critical R and T activities in materials, heat-pipes, component analyses, and system studies. This initiative is also applicable to space propulsion as well as power, and applies to solar as well as nuclear energy.

3 - SPHINX B/C (118) Lewis Research Center

	FY 78	FY 79	FY 80	FY 81	FY 82	FY 83
Funding (Total)	2.1	3.4	1.8	0.3	0.2	0.1
Manpower	35	42	30	13	10	5

This project provides engineering data on high voltage space systems exposed for a long time to the environment of space and demonstrates technology readiness for auxiliary electric propulsion systems. This new start is a vital element of many future space requirements including the generation of large amounts of solar power in space and the stabilization and control of large structures.

4 - Gallium Arsenide Solar Cell Arrays (132) JPL

	FY 78	FY 79	FY 80	FY 81	FY 82	BTC	Total
Funding (Total)	0.5	0.5	1.0	1.0	1.0	3	7
Direct Manpower	5	5	7	7	7		

Objective: The goal of this initiative is to procure and evaluate in space a 1-kW Ga As solar cell array with an efficiency greater than 18%. Gallium Arsenide cells are potentially superior to silicon solar cells because: (1) they may have greater efficiency, (2) they are more radiation resistant, (3) they can operate at higher temperatures to take advantage of solar concentrators, and (4) they are potentially lighter in weight and lower in cost because Ga As cells need be only several micrometers in thickness compared to 100-200 micrometers in silicon. Gallium Arsenide arrays could also be effective as converters for laser beams in energy transmission applications.

5 - Feasibility of Gaseous Fuel Power Reactor Concept
(Program Augmentation) (OAST-RR)

	FY 78	FY 79	FY 80	FY 81
Funding				
Current Plan	1.0	1.0	1.0	1.0
Augmented	1.0	2.0	2.0	2.0
Manpower	3	4	4	4

This initiative expands the current level of effort in research on gaseous fuel reactors to demonstrate the feasibility of gaseous-fuel reactors for space power use by FY 1981. This test would use uranium hexafluoride fuel in a test rig currently in operation at the Los Alamos Scientific Laboratory. The technical goals would be operation in the power range of 10 kW-100 kW with a fuel temperature of 1500 K. A successful test at these conditions should demonstrate all essential features of a gaseous fuel reactor for space power use and would be the precursor for later high temperature tests related to propulsion applications. This program would also have substantial benefits for the terrestrial use of nuclear power. No long range commitment beyond FY 1981 is implied by this initiative.

Related New Initiatives - FY 1978
(In Other Themes)

- 104 Development of Dexterous Manipulator
- 105 Attitude Control and Figure Control of
Large Deformable Structures
- 114 Large Space Structures Technology
- 120 Development and Demonstration of Silver/Hydrogen
Rechargeable Battery Systems
- 128 Advanced Technology Laboratory

Deferred New Initiatives

- 130 Orbital Flight Demonstration of Large Space Structures
for Solar Power Satellite (MSFC) From 1978 to 1979 or later

Potential New Initiatives 1979 and Beyond

- 303 Photochemical Solar Conversion
- 306 Low-cost Isotope-Fueled Space Power System
- 308 Second Generation H_2/O_2 Fuel Cell
- 312 Brayton Isotope Power System Flight Demonstration
- 313 Solar Spectrum Measurements
- 314) Solar Array Materials Tests in Space
- 315) and Correlation with Ground Tests
- 320 Space Calibration of Solar Cells

Appendix A

MSPP Power Requirements

Estimates have been made of power requirements for three categories of future space missions (1990-). For the space manufacturing, and satellite and space station operational power categories, a range of at least 10 - 100 Kw is required. Two Mw are needed for one proposed passive radar system, and propulsion system requirements are in the range 100 Kw - 100 Mw.

MISSIONS (Applications):

I. Propulsion Systems

- A. Low-Thrust Hydrogen Monopropellant Tug (Altitude = 350 Km to synchronous)
Estimated requirements for transfer of a 1,000 pound payload from a 350 Km circular orbit to geosynchronous -

Initial mass, $m_0 = 1,500$ Kg

Propellant mass, $m_p = 500$ Kg

Specific impulse, $I_{sp} = 1,000$ sec. (ref.1)

Burn time, $t_b = 10$ days

The total Δv required, if a conventional 2-burn maneuver accomplished the transfer, would be

$$\Delta v_{2\text{-burn}} \approx 3,875 \text{ m/sec}$$

The "equivalent" Δv for the continuous low thrust burn will be somewhat larger, say 50 percent more. The required thrust is then calculated for the mean total mass and an averaged acceleration:

$$T = \bar{m} \bar{a}$$

$$= 1250 \text{ Kg.} \frac{3875 \text{ m/sec} \times 1.5}{10 \text{ days} = 864,000 \text{ sec}}$$

$$T = 8.4 \text{ newtons, less than 2 lb.}$$

The power required to heat the hydrogen to achieve the exhaust velocity needed is then given by

$$P = \frac{1}{2} \dot{m} V_{EXH}^2 = \frac{1}{2} T V_{EXH}$$

$$V_{EXH} = I_{sp} g = 9807 \text{ m/sec}$$

Thus,

$$P = \frac{1}{2} (8.4 \text{ nt}) \times 9807 \text{ m/sec} = 41.2 \text{ Kw}$$

Assuming an efficiency of a little less than $\frac{1}{2}$ for the power conversion system, the input power required at the receiver is

$$P_{\text{input}} = 100 \text{ Kw}$$

B. Larger Thrust Remotely Powered Propulsion Systems (Altitude = 350 Km to synchronous)

From the equation for the power P in Part A above, it is seen that for a constant exhaust velocity, the required power is proportional to the thrust T. For acceleration of the same payload at about 1g vs $\sim 10^{-3}g$ above, an input power $\sim 100 \text{ Mw}$ is required. This latter number is supported by the statement in reference 1, p. 4-21, calling for a laser of the scale $10 - 100 \text{ Mw}_e$ for effective use in propulsion.

II. Manufacturing in Space

- A. A strong candidate for space manufacture is high-purity tungsten for x-ray tube targets. (altitude = 250 to 600 Km) The power required to keep a mass of tungsten molten is quite large due to its high melting temperature. Making the assumption that the molten sphere radiates with an emissivity of unity (black body), and that none of the thermal radiation is reflected back upon the surface, the power required to just hold a 1 Kg mass molten is

$$\begin{aligned} P &= q_{\text{RAD}} = \sigma A_{\text{surf.}} T_{\text{melt}}^4 \\ &= \sigma \left[36\pi \left(\frac{m}{\rho} \right)^2 \right]^{1/3} T_{\text{melt}}^4 \\ &= 5.6686 \times 10^{-15} \frac{\text{Kw}}{\text{cm}^2 (\text{K})^4} \left[36\pi \left(\frac{1,000 \text{ gm}}{18.85 \text{ gm/cm}^3} \right)^2 \right]^{1/3} (3643^\circ \text{K})^4 \\ P &= 68 \text{ Kw} \end{aligned}$$

This can be reduced by use of a reflector to conserve heat, and will decrease proportionately as the actual emissivity, which is less than 1.

In reference 2, a heating power of 21 Kw is estimated for a 2 cm. radius (647 gm) sphere of molten tungsten, and 1.3 Kw for a 10 gm sample, assuming an emissivity of 0.4. An inductive heating system was studied, with a 6250 ampere turns coil and 400 KHz excitation frequency. A 10 percent efficiency was estimated, requiring a heating system power up to 200 Kw for a mass of only 647 gm.

- B. Production of Si crystals by the floating zone method (ref. 3) (altitude = 250 to 600 Km) "Up to 20 Kw may be required to produce a 3-4 inch diameter specimen. A reflector could reduce this to around 5 Kw."

Using an electron bombardment heating system, much more efficient than induction heating, the input power required for melting at very high temperatures is of the order

$$P_{\text{input}} = 10 - 100 \text{ Kw}$$

III. Operational Power for Satellites and Space Stations (Altitude = 250 Km to synchronous)

- A. Space Station, 10 man crew - A number of studies have conclusively shown that the required operational power is of the order

$$P_{\text{REQ.}} = 10 - 100 \text{ Kw (250-600 Km)}$$

- B. Unmanned Satellites - Communications, weather, Earth observations, Surveillance (ref. 4) (Altitude = 250 Km to synchronous)

Medium Power -

$$P_{\text{REQ.}} = 1 - 10 \text{ Kw (10's of them operational)}$$

High Power -

$$P_{\text{REQ.}} = 1 - 2 \text{ Mw (1 or 2 of this scale)}$$

REFERENCES

1. A Forecast of Space Technology, 1980-2000.
2. Contractors Report CR-120287, "Study of Identification of Beneficial Uses of Space (BUS)," Nov. 1, 1973. (General Electric Co.)
3. McDonnell Douglas "Manned Orbital Systems Concepts (MOSC) Study, 2nd Monthly Report, Nov. 1974, p. 19.
4. Study of the Commonality of Space Vehicle Applications to Future National Needs, Aerospace Corporation Report No. ATR-75 (7365)-2, March 1975.

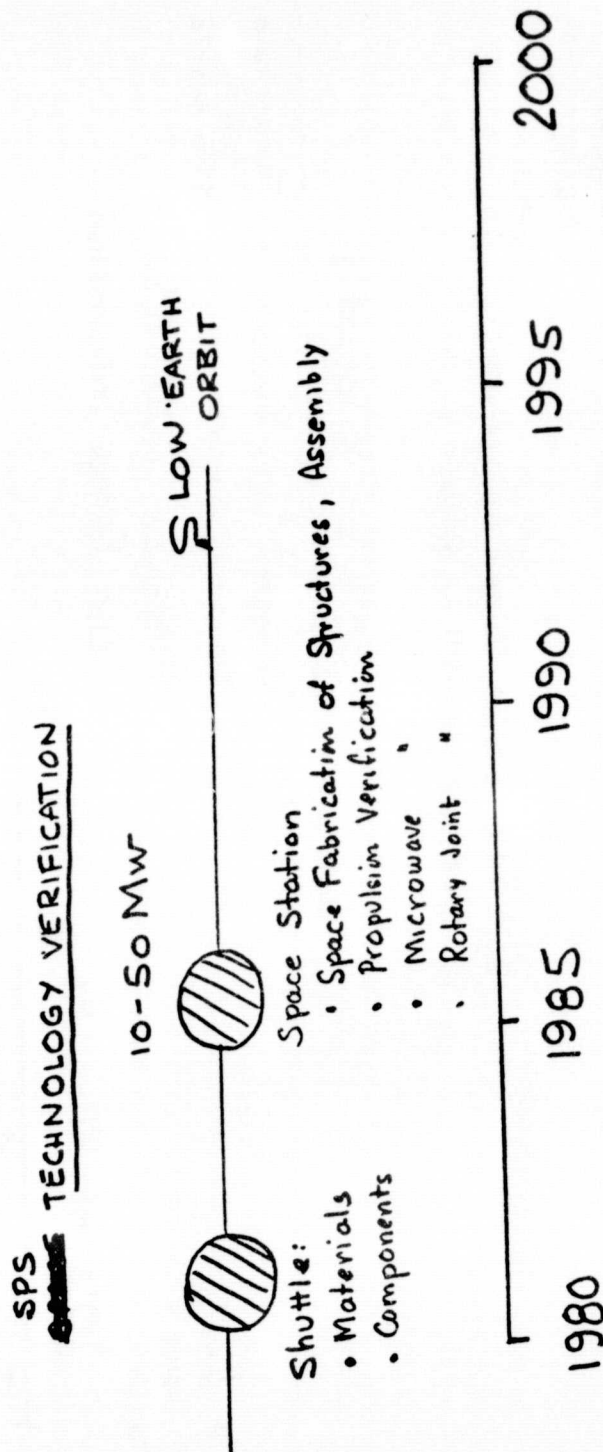
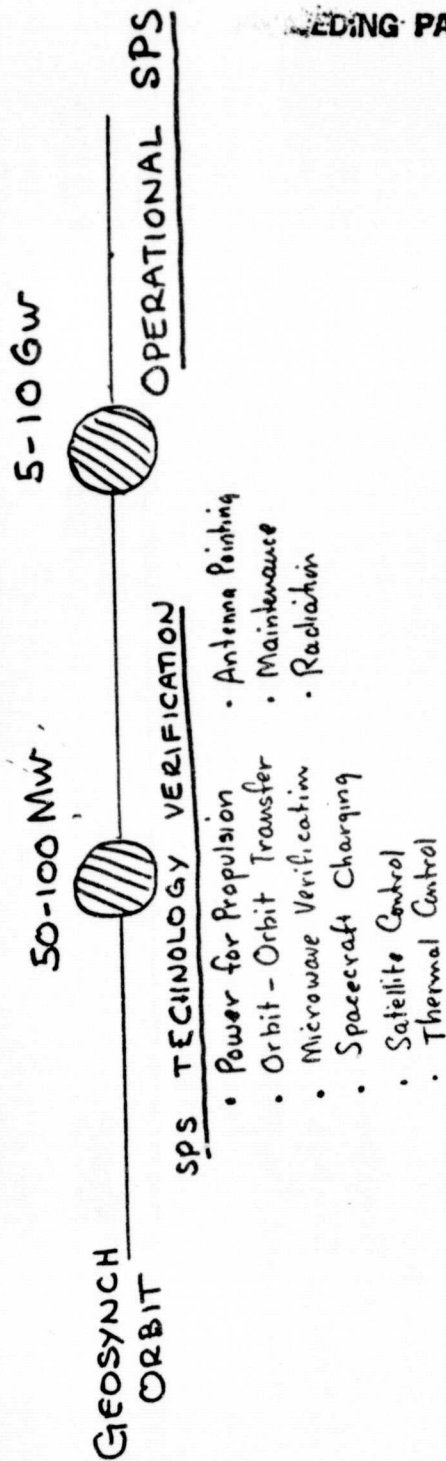


FIGURE 2 - STRAWMAN SCHEDULE FOR EARLY SPS

10's of Megawatts
 Large Solar
 Nuclear (Gas Core)
 etc.

Both LEO & GSO Power Applications
 Propulsion as well as power

100's of Kilowatts

Advanced Solar Systems } Photovoltaic
 Advanced Nuclear " } Brayton
 Microwave Transmission Thermionic
 Laser Energy Transmission

Primarily
 Low E.O.

10's of Kilowatts

Technology Areas

Solar P.V.
 Isotope Brayton
 Energy Storage
 Microwave Transmission

 1980 1985 1990 1995 2000

FIGURE 1 STRAWMAN MSPP SCHEDULE FOR SPACE USES

*Multipurpose
Space
Power
Platform(s)*

APRIL 26, 1976

10's of Megawatts
 Large Solar
 Nuclear (Gas Core)
 etc.

Both LEO & GSO Power Applications
 Propulsion as well as power

100's of Kilowatts

Photovoltaic
 Brayton
 Thermionic

}
 Advanced Solar Systems
 Advanced Nuclear "

Microwave Transmission
 Laser Energy Transmission

Primarily
 Low E.O.

10's of Kilowatts

Technology Areas

Solar P.V.
 Isotope Brayton
 Energy Storage
 Microwave Transmission

2000

1995

1990

1985

STRAWMAN MSPP SCHEDULE FOR SPACE USES

1980

FIGURE 1

MSPP

MODEL 2

1-10 Megawatts

GEOSYNCHRONOUS
ORBIT



SPACE BASE SUPPORT

" INDUSTRIALIZATION, MFG.

LASER ORBITAL TRANSFER VEHICLE

TECHNOLOGY DEMO FOR SPS DECISION

MSPP MODEL 1

100-200 Kwe



LOW EARTH ORBIT

Support Shuttle Payloads

Power Plant for Space Station

20-30 Kwe Laser Power Transfer Demo.

1980

1985

1990

1995

2000

FIGURE 3 - STRAWMAN MSPP SCHEDULE FOR SPACE USE
AND FOR SPS TECHNOLOGY DEMONSTRATIONS

MSPD thrusts

- Megawatt Solar
- Advanced Energy Conversion
- Environmental
- Laser Power Transfer
- Nuclear Power Option

MSPD

— a concept

23

CENTRAL

POWER STATIONS
FOR

SPACE MISSIONS

MSPD

- technology

for

SPS

MSPF functions

GENERATION

STORAGE

TRANSFER

(other)

MSP profile

1980

→

L.E.O.

— G.S.O

KW's

— MW's

SOLAR

— NUCLEAR

MSPDP users

- SHUTTLE PAYLOADS
- SPACE STATIONS
- SPACE MANUFACTURE
- APPLICATIONS
- OTV PROPULSION

MSPD energy transfer

• WIRE, BUS BAR

• MICROWAVE

• LASER

• STORAGE UNIT

ENERGY TRANSFER by Laser

- CO ELECTRO GASDYNAMIC
- 60% LASER EFFICIENCY
- 70% RECEIVER EFFICIENCY
- 40,000 km RANGE
WITH 30 m OBJECTIVE

MSPD

Strawman schedules

- Megawatts by 2000

- Megawatts by 1990

MULTIPURPOSE SPACE POWER PLATFORMS

(7)

Summary Comments on Workshop Activity

During the early phase of the workshop activity, the theme team for multi-purpose space power platforms (MSPP) developed a target schedule for technology planning shown on the attached figure I-C-1. This schedule was constructed by considering planning activities currently underway in the Offices of Space Flight and the Offices of Energy Programs. As far as the MSPP concept is concerned, this schedule shows a platform in low-earth-orbit with a power rating of 100 to 200 Kwe in the 1983 time period and a 1 to 10 megawatt platform in geosynchronous-earth-orbit in 1988.

These ambitious goals required the working group to consider technologies which could be made available in the near time period. In consequence, technology for advanced power system concepts does not appear as supportive of this theme. A more relaxed MSPP schedule would allow the investigation of a wider range of technical options for future platforms. This is an issue the theme team must consider with OAST and other program offices to assure that the MSPP theme uses the proper schedules for planning technologies and, thereby, advocates the best mix of technologies.

The application of MSPP's in transferring power for OTV propulsion received considerable interest in the working groups. It is an area for further study to assess capabilities and determine requirements, because this application could develop major needs for MSPP's.

The major need of the MSPP concept is study of its applications and benefits in NASA, military, and commercial space missions. The OASIS new start submitted by LeRC fulfills this need, but it should be expanded in scope to develop the MSPP concept properly.

The highest priority technology area for MSPP is that dealing with the problems of interactions with high-voltage systems with space plasmas. Sphinx B/C is, therefore, the major critical new start for MSPP, and a new start for theoretical studies in this area of technology should also be planned. A priority listing of all technology areas of need for the MSPP concept are listed below:

- High-voltage power system technology
- Large structures for MSPP
- Solar power
- Power transfer
- Materials technology
- Energy storage

To support MSPP operations, an OTV will be needed to carry a large power station to GSO.

4/26/76

MULTIPURPOSE SPACE POWER PLATFORM

1976 80 84 88 92 96 2000

SPACE STATION

LEO LEO GEO
 4-6 Man 10-20 Man 3-6 Man

MANNED OTV

△

MSPP

LEO 100-200 kw
 GEO 1 Mw
 Higher Power

LEO MSPP

- o Develop SEPS & SPS technology
- o Power initial LEO Space Station
- o Develop laser transfer technology
- o Develop laser powered OTV concept

GEO MSPP

- o Laser power for 50-100 kw payload OTV
- o Deploy with manned OTV
- o Power initial GEO space station
- o Verify SPS technology
- o Provide power for initial SPS construction base

Fig. I-6-1

OVERALL THEME TECHNOLOGY RANKING AND
INITIATIVE ACTION

DATE 4/30/76

TECHNOLOGY NEED NO	OVERALL T.T. PRIORITY	INITIATIVE ACTION		
		REVISE EXISTING INITIATIVE	DRAFT NEW INITIATIVE	NONE REQUIRED
HIGH VOLTAGE POWER SYSTEM TECHNOLOGY	1			
- 07-P2-E1/3A Sphinx B/C				X
- Theoretical Investigations of Space Plasma Effects on High Power/Voltage Space Systems			X	
- 07-E3-8 Charge State Measurement				
TECHNOLOGIES FOR USE OF LARGE STRUCTURES	2			
IN SPACE POWER PLATFORMS				
- 07-E1-15 Attitude, Figure Control and Stab. of Large Space Struct.				
- 07-E3-1 Alignment Sensing				
- 07-M2-1 Space Deployable Structures				
- 07-M2-2 Space Assembly of Large Structures				

TT MSPP - 07

OVERALL THEME TECHNOLOGY RANKING AND
INITIATIVE ACTION

TECHNOLOGY NEED NO	OVERALL T.T PRIORITY	INITIATIVE ACTION		
		REVISE EXISTING INITIATIVE	DRAFT NEW INITIATIVE	NONE REQUIRED
SOLAR POWER TECHNOLOGY	3			
- 07-P2-PC-2 Lightweight Radar Resist. Solar Arrays				
- 07-P2-PC-7 Solar Array Technology for SEP and P/L Applications				
- 07-E3-9 Radiation Dose Measurement				
POWER TRANSFER	4			
(07-E2-24)				
- 07-P2-TX3 Laser Power Transmitter			X (2)	Current Work May Be Adequate
- 07-2P-TX2 Laser Power Converter			X (?)	"
- Research on Advanced Propulsion Based on Power Transfer			X (?)	"
- 07-M2-01 Deployable Laser Mirror				
			Determine Need for NASA Effort in Light of DARPA Planned Studies	

OVERALL THEME TECHNOLOGY RANKING AND
INITIATIVE ACTION

TT MSPP - 07

FORM V
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DATE 4 / 30 / 76

TECHNOLOGY NEED NO	OVERALL T.T PRIORITY	INITIATIVE ACTION		
		REVISE EXISTING INITIATIVE	DRAFT NEW INITIATIVE	NONE REQUIRED
MATERIALS TECHNOLOGY	5			
- 07-M1-01 Power Generation Materials and Processes				
- 07-M1-02 Power Storage & Transmission Materials and Processes				
ENERGY STORAGE	6			
- 07-P2-ES6 Large Ni-Cd Battery				
- 07-P-ES8 Photovoltaic/Electrolysis Fuel Cell Technology				
SUPPORTING MISSION NEEDS				
OTV for GEO in 1988 Data Management				